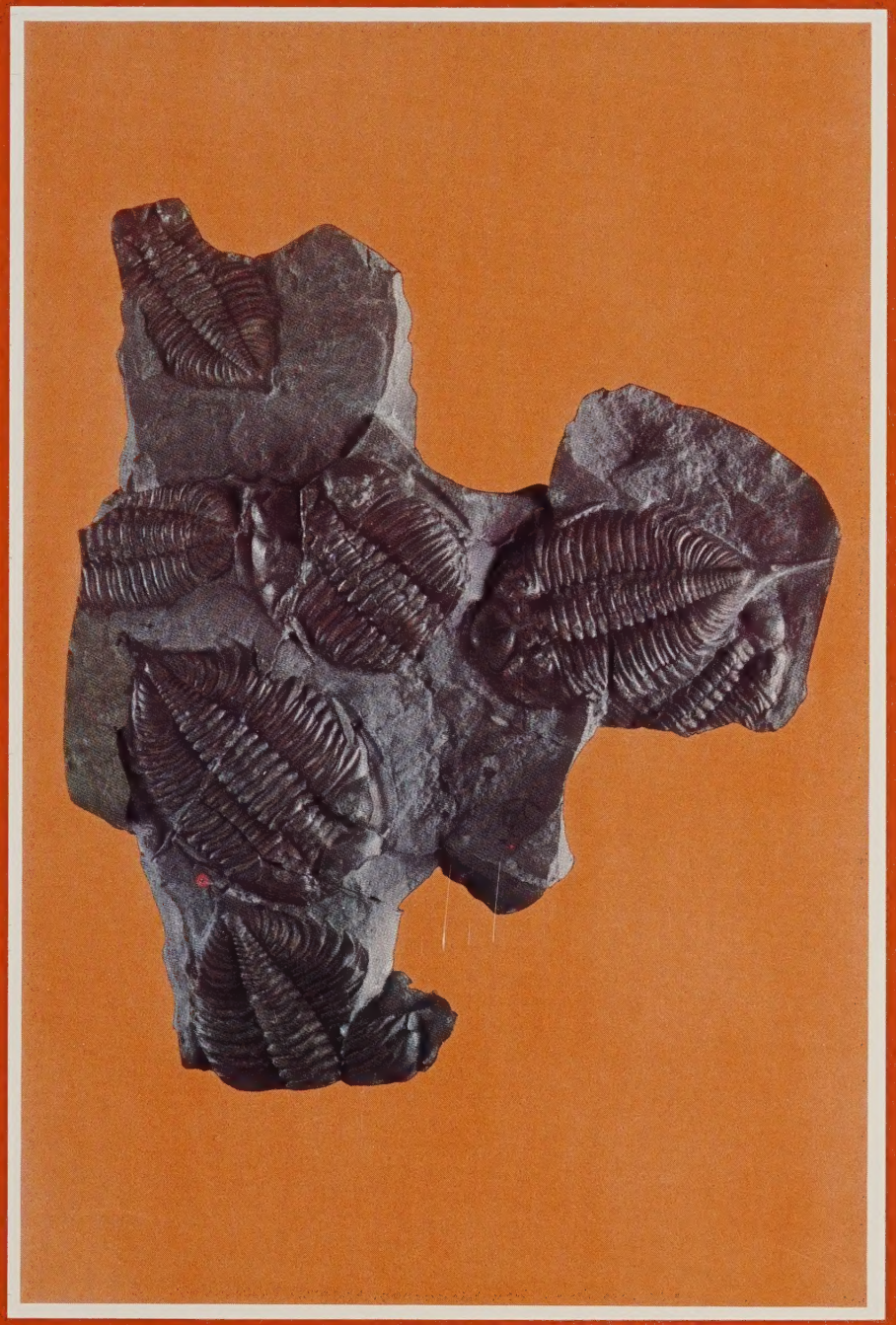
ROM ENCOUNTER SERIES

An Introduction to Ontario Fossils

Janet Waddington



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100 Queen's Park, Toronto, Ontario, Canada M5S 2C6

Printed and bound in Canada at THORN PRESS

School edition ISBN 0-88854-250-X
Trade edition ISBN 0-88854-251-8

Cover photograph by Bill Robertson, Royal Ontario Museum: Trilobites *Dalmanites limulurus.* Middle Silurian, Rochester Formation, St. Catharines (¾ actual size).
Map by John Thimidis

Photographs

All fossil specimens are from the Department of Invertebrate Palaeontology except Figure 23.
Art Department, Royal Ontario Museum: Figure 6C, 7C, 8B, 19B.
D. H. Collins, Royal Ontario Museum: Figure 1A.
Department of Vertebrate Palaeontology, Royal Ontario Museum: Figure 9.
James D. Eckert: Figure 1B, 3, 10, 11A, 14, 16B, 17B, 21, 23 (courtesy Department of Vertebrate Palaeontology, Royal Ontario Museum).
Rolf Ludvigsen: Figure 8A.
Photography Department, Royal Ontario Museum: Figure 1C, 2A, 2B, 11B, 17A, 18A, 18B, 19A, 20A, 20B, 24.
Bill Robertson, Royal Ontario Museum: Figure 4, 6B, 7A, 7B, 12, 13, 15.
David M. Rudkin, Royal Ontario Museum: Figure 6A, 16A, 22.
Janet Waddington, Royal Ontario Museum: page 3.

Canadian Cataloguing in Publication Data

Waddington, Janet, 1948–
An introduction to Ontario fossils

(ROM encounter series)

Bibliography: p.

ISBN 0-88854-250-X pa. (school ed.)
ISBN 0-88854-251-8 pa. (trade ed.)

1. Paleontology — Ontario. I. Title. II. Series: Royal Ontario Museum. ROM encounter series.

QE748.05W33 560.9'713 C79-094722-6

The fossil record

> I look at the natural geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating to only two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page only here and there a few lines.
>
> *Charles Darwin*

Charles Darwin saw the fossil record as an incomplete history, and this is certainly true of the history of life as we can read it in Ontario's rocks. It begins hundreds of millions of years ago, but it is interrupted for periods far longer than the recorded periods.

Rocks of various ages underlie the soil and vegetation of Ontario's landscapes. In some places the solid rock is completely covered by loose sediment; in others it lies at or near the surface. Wherever layered rocks are exposed in Ontario, there is a good chance of finding *fossils*—the remains of ancient plants and animals, *organisms,* preserved in the rocks.

Looking for fossils along Forty Mile Creek near Grimsby.

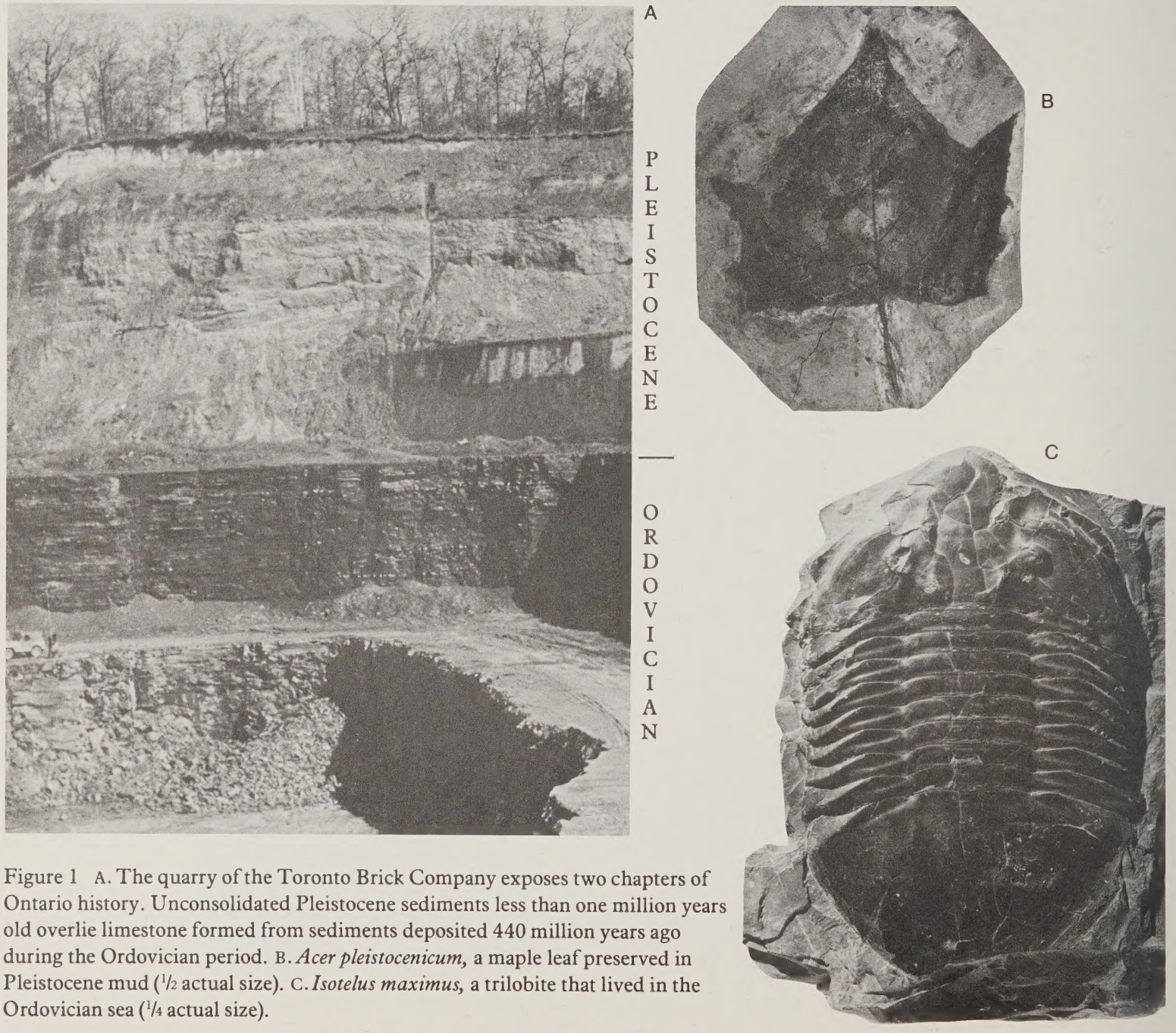


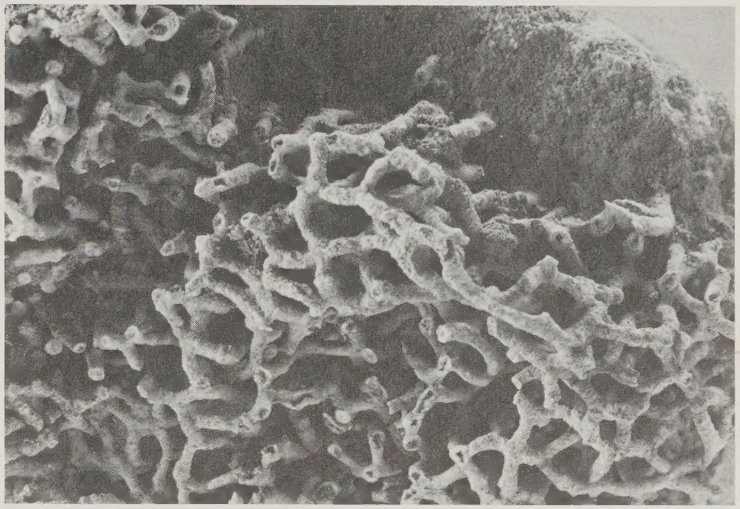
Figure 1 A. The quarry of the Toronto Brick Company exposes two chapters of Ontario history. Unconsolidated Pleistocene sediments less than one million years old overlie limestone formed from sediments deposited 440 million years ago during the Ordovician period. B. *Acer pleistocenicum,* a maple leaf preserved in Pleistocene mud (1/2 actual size). C. *Isotelus maximus,* a trilobite that lived in the Ordovician sea (1/4 actual size).

How are fossils formed?

Studying natural processes today makes us wonder that anything is preserved at all, for when a plant or an animal dies it is usually completely recycled. Soft tissue such as leaves or flesh either is eaten or it decays through bacterial action until there is no trace of it left. Hard parts such as shell, bone, or wood are more resistant to decay, but they too are usually broken down gradually—through the action of wind, water, and tiny organisms—and become part of the soil.

Only if the plant or animal is shielded from these agents soon after death is there a slight chance that part of it may be preserved. Quick burial is one method of shielding it from destruction. Burial is most likely to occur in areas where sediments accumulate rapidly—on ocean or lake bottoms or in swamps. It is least likely to occur in areas where no sediment accumulates or there is active erosion —on dry land or in fast-flowing water. Thus the chance that an animal or a plant will become a fossil depends as much on where it lives as on what it is made of.

Many changes occur in the remains of an animal or a plant as it becomes fossilized. After burial the fleshy parts generally decay and disappear. (For this reason animals without hard skeletons are rarely found as fossils.) Shell, wood, and bone may be preserved unchanged, but more commonly they are altered by chemicals in the ground water seeping through them. The pores in bone or wood may become filled with minerals such as silica and literally turn to stone (*petrification*). The original material of the hard parts may be changed to a completely different material while retaining the same shape and structure (*replacement*). Sometimes a shell dissolves to leave a cavity or *mould* of the original in the sediment. Later this mould may be filled in to form a *cast* or replica of the shell (Figure 2). Sometimes, especially with plants, the remains



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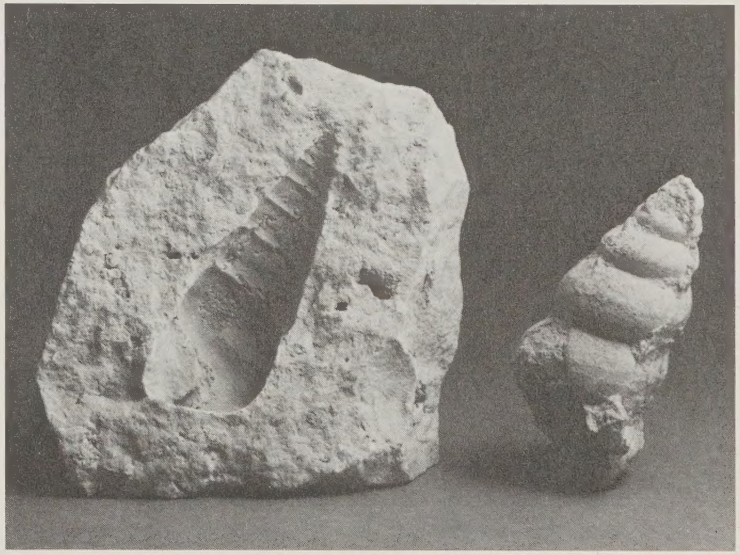


B

Figure 2 A. Replacement: the coral *Syringopora retiformis* has been replaced with silica, making it more resistant to erosion than the surrounding rock. Middle Silurian, Fossil Hill Formation, Owen Sound (1½ times actual size). B. Natural mould (left) and cast (right) of the snail shell *Michelia macrospira*. Middle Silurian, Guelph Formation, Elora (⅔ actual size).

Figure 3 *Arthrophycus alleghaniensis,* a trace fossil consisting of a maze of animal burrow fillings. Middle Silurian, Grimsby Formation, Hamilton ($^1/_3$ actual size).

are broken down chemically to form a thin carbon film (*carbonization*).

Other types of fossils are not formed directly from the remains of animals. Among these are *impressions* left in soft mud, and *trace fossils*—tracks, trails, and burrows made by animals as they went about their daily business (Figure 3). Very rarely the entire remains of ancient organisms may be found unchanged. For example, complete mammoth carcasses have been found preserved in the Arctic permafrost of Siberia and Alaska.

Once a fossil is formed it may still be changed, or even destroyed, by processes within the earth's surface which alter the rocks in which the fossil is buried. Fossils start out as animal or plant remains buried in layers of sediment—sand, mud, or gravel. In time these layers of sediment themselves are buried, harden, and become *sedimentary rocks.* The rocks may be uplifted and eroded, or excavated to expose the older underlying layers. Until this happens the fossils in the rocks are usually inaccessible to man.

A calendar in the rocks

Since fossils are the record of past life, is there any way of knowing how long ago they lived? Fossils are preserved in sediments laid down in layers or *strata,* one on top of another. Thus the lowest layers must have been deposited first and be older than any layers overlying them. However, the appearances of the rocks vary from place to place, making it difficult to recognize rock strata of the same age in different places.

In the late 1790s a surveyor named William Smith made a detailed study of the rocks and fossils he found while working on a canal project in England. He noticed that each different layer in the rocks contained a distinctive group of fossils. Furthermore, he discovered that from place to place across England the fossil groups always appeared in the same order. Thus the distinctive combinations of fossils could be used to identify the rock strata. This knowledge formed the basis for a calendar of earth history—a geological time scale (Table 1).

The time scale inspired by Smith's work tells us the order in which things occurred—without any dates. Reading the fossils is a bit like looking through an old album with no labels on the photographs. Dress styles, car models, the presence or absence of certain objects in a familiar landscape are all clues which combine to give an accurate sequence of events even if dates are missing. While mini skirts may come back into fashion from time to time, mini skirts *and* the Beatles at the same time happened only once. In the same way, one particular type of fossil may appear in rocks of different ages, but it is found in combination with certain others only at one specific level.

Geological time has been divided up into periods, similar to periods of modern history, for example, Victorian, Georgian, and Elizabethan. These units of time

Table 1 Geological Time Scale
The Calendar of Earth History

ERA	PERIOD	BEGAN MILLION YEARS AGO	OCCURRING IN ONTARIO
Cenozoic	Quaternary — Recent, Pleistocene	2	
	Tertiary	65	
Mesozoic	Cretaceous	136	
	Jurassic	190	
	Triassic	225	
Palaeozoic	Permian	280	
	Pennsylvanian	325	
	Mississippian	345	
	Devonian	395	
	Silurian	430	
	Ordovician	500	
	Cambrian	570	
PRECAMBRIAN		3700±	
Formation of crustal rocks Origin of the earth		4600±	

are not all of the same length, but are periods in which certain events occurred or certain monarchs reigned. The evidence for events in modern periods may be seen in furniture and buildings; the evidence for geological periods is found in the fossils. The geological periods are grouped into eras, representing major blocks of earth history, just as recorded human history is broken down into, for instance, B.C. and A.D. A glance at the names of these eras reveals the influence that fossils have had in the development of the time scale. *Palaeozoic, Mesozoic,* and *Cenozoic* mean "ancient", "medieval", and "modern" life respectively.

The geological time scale deals with *relative time.* It may tell us that a certain rock layer is older or younger than another, but it does not give the age of either layer in years. *Absolute time,* the age of rocks in years, can be determined by analysis of radioactive materials in the rocks. These materials break down spontaneously at a constant rate, different for each element, to form different substances. For example, uranium changes to lead, and potassium produces argon. Since scientists know the rate of change and can measure the relative amounts of uranium and lead or potassium and argon in rocks, they are able to calculate the time interval since the rocks formed, that is, the age of the rocks. In this way an absolute time frame has been added to the relative time scale for earth history.

The names in the geological time scale refer only to the periods of time during which the sediments that form the rocks were laid down. During any one period, a great variety of rocks formed. These have been further subdivided by geologists into *formations*—units defined by actual physical features such as the colour, the texture, and the chemical composition of the rock. Thus period refers to the age of the rocks, while formation refers to the specific rock layers in a particular region.

Ontario's story

Ontario was not always the land that we know now. A journey back in time would reveal periods when Ontario lay under a tropical ocean and others when all the land was covered by ice. Some of the story is preserved for us in the rocks and fossils of different ages. Much of it has been erased forever.

Precambrian

About two-thirds of Ontario is underlain directly by the very ancient Precambrian rocks of the Canadian Shield. Some of these are sediments which for the most part have been so changed by heat and pressure that they are no longer recognizable as sediments. The Precambrian was originally defined as the whole period of time before life began and for many years Precambrian rocks were thought to contain no fossils. In the area around Thunder Bay, however, there are rocks that have been altered very little since they were deposited under water as iron-rich sediments almost two billion years ago. When pieces of a particular unit called the Gunflint Chert are dissolved in hydrofluoric acid, the residue is found to contain the microscopic remains of early organisms. These *microfossils* include thin threads resembling present-day filamentous bacteria and blue-green algae, spherical bodies similar to single-celled algae and bacteria, and strange star-shaped, umbrella-shaped, and parachute-shaped forms. Similar tiny parachute-shaped organisms have been found living today in the ammonia-rich soil packed against the walls of an ancient castle in Wales.

Discovery in Ontario of well-preserved Precambrian microfossils set the stage for current research that has pushed the date of the origin of life on earth back as far as 3500 million years ago. Earth itself is thought to be about 4600 million years old.

Not all Precambrian fossils are microscopic. Within the Sibley Group of rocks near Thunder Bay are found large fossil *stromatolites* (Figure 4). These layered, cone-shaped mounds, packed together like a giant pan of cinnamon buns, were formed when blue-green algae growing in tidal lagoons 1400 million years ago trapped sediment between their jellylike filaments. Stromatolites are still being formed by blue-green algae in the very salty waters of Shark Bay, Western Australia.

Palaeozoic

Although Precambrian rocks represent a vast length of time, they contain very few fossils. Ontario's major fossil record is found in the Palaeozoic rocks which cover much of southern Ontario and the James Bay Lowlands. In the time between 450 and 350 million years ago (during the Ordovician, Silurian, and Devonian periods), Ontario was repeatedly covered by warm, shallow inland seas in which lived a great variety of animals and plants. The extent of the seas varied, but they periodically covered the eastern half of Lake Superior, the rest of the Great Lakes region, and much of the area between Lake Huron and Hudson Bay. The seas, fed by rivers draining the bordering highlands of the Canadian Shield, acted as settling basins for thousands of metres of sand, mud, and clay. Over the years these sediments, which trapped the remains of many sea creatures, have turned to sandstone, limestone, and shale.

During these 100 million years, Ontario is thought to have been within about 20 degrees of the equator. This

figure has been determined in part through *palaeomagnetism*. Tiny particles of a magnetic material such as magnetite lined themselves up in soft mud to point towards the magnetic North Pole. When the mud turned to rock, these tiny compasses were frozen in time to point forever in the direction the pole lay before the mud hardened. By taking palaeomagnetic readings from rocks of the same age from all over the continent, it is possible to determine the approximate positions of the equator and the poles in relation to the continent at different times in earth history.

Further evidence that Ontario was close to the equator during the Palaeozoic era is found in the variety and particular kinds of different fossils in the rocks. Tropical waters today support a much more colourful and varied population of organisms than do cooler areas. The same was true in bygone eras; the underwater scene over much of Ontario must have resembled views of the Caribbean or Australia's Great Barrier Reef.

The Palaeozoic rock strata of southern Ontario are for the most part flat-lying, with a slight downward tilt or dip towards the southwest. Because of this dip the strata

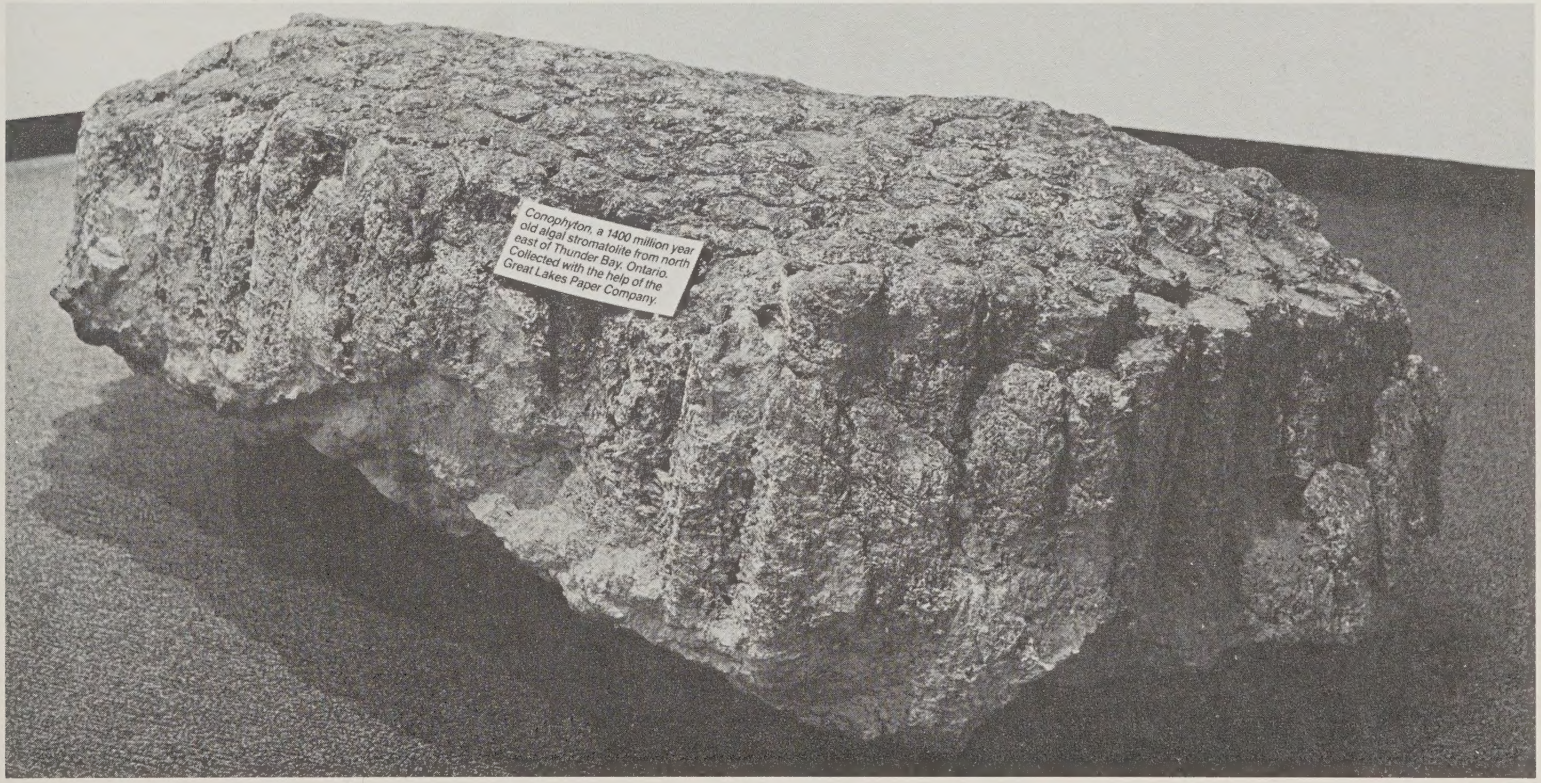

Conophyton, a 1400 million year old algal stromatolite from north east of Thunder Bay, Ontario. Collected with the help of the Great Lakes Paper Company.

Figure 4 *Conophyton* sp., a stromatolite formed by algae. This specimen weighs nearly a tonne. Precambrian, Sibley Group, near Thunder Bay.

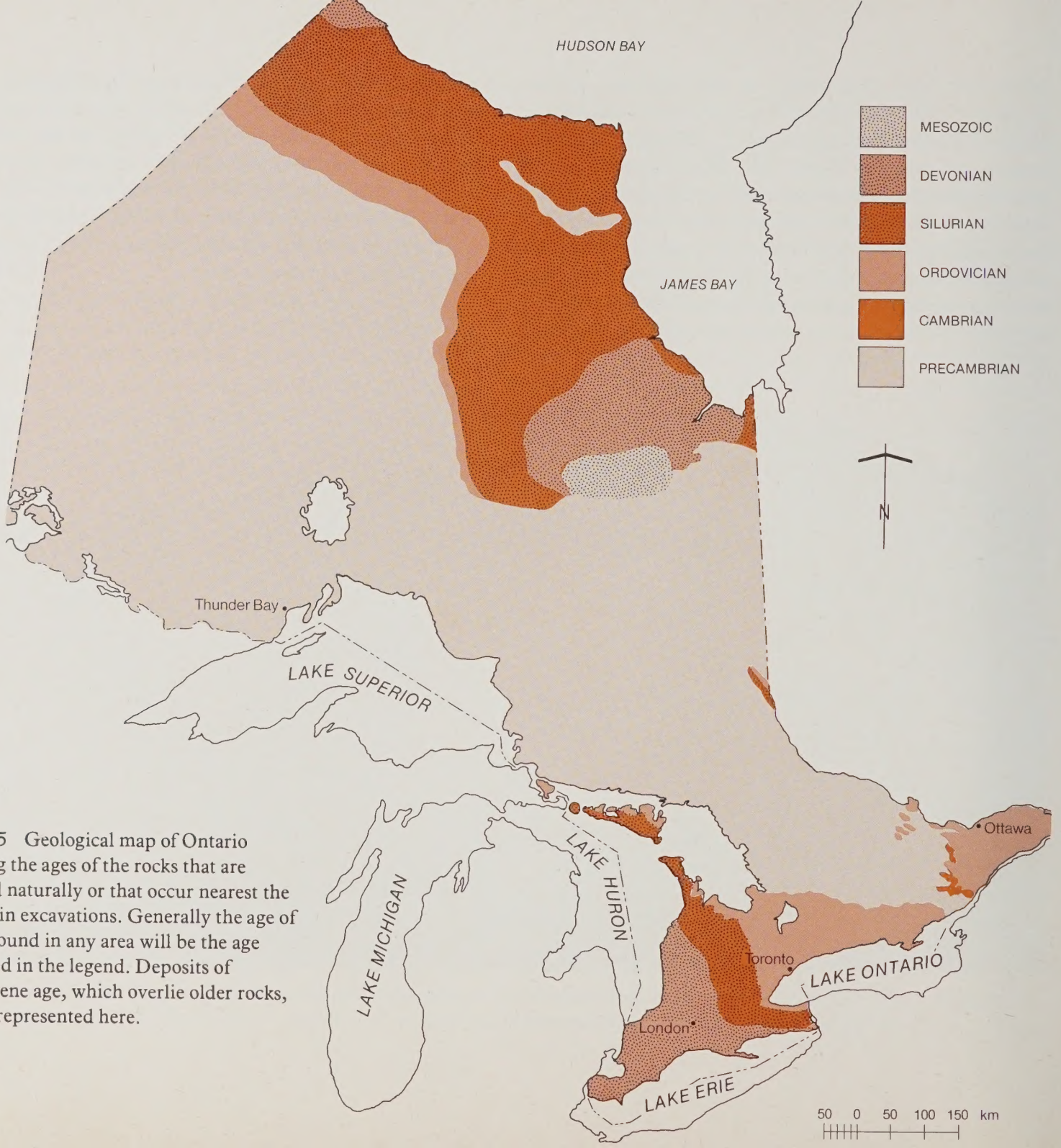


Figure 5 Geological map of Ontario showing the ages of the rocks that are exposed naturally or that occur nearest the surface in excavations. Generally the age of fossils found in any area will be the age indicated in the legend. Deposits of Pleistocene age, which overlie older rocks, are not represented here.

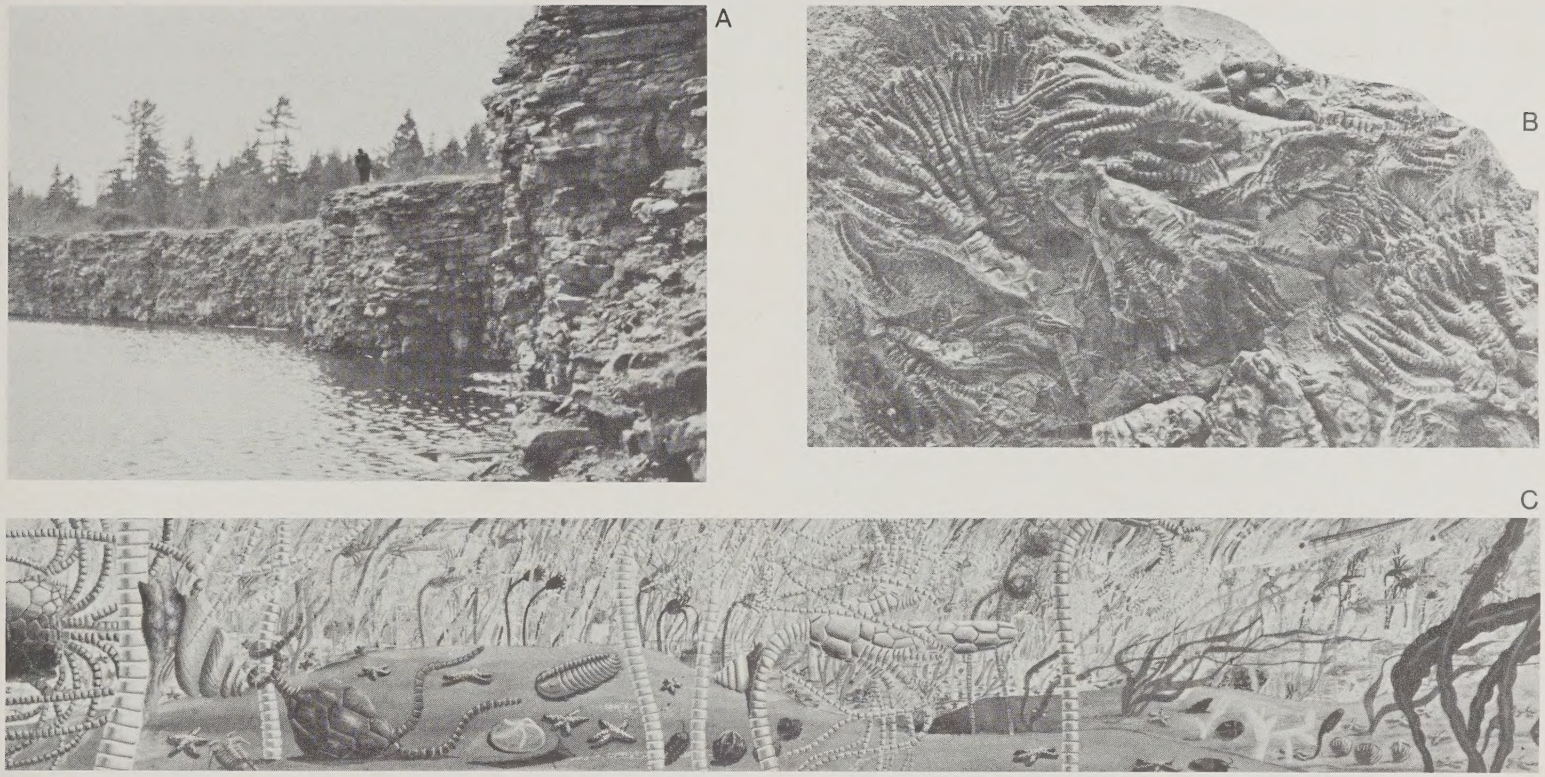


Figure 6 A. In quarries such as this one near Kirkfield, rocks and fossils which would otherwise remain hidden are exposed. B. Rock slab from the Kirkfield quarry containing several specimens of the sea lily *Cupulocrinus jewetti.* Middle Ordovician, Bobcaygeon Formation (1/2 actual size). C. Fossils from the Kirkfield quarry have led palaeontologists to make this reconstruction of a Middle Ordovician sea floor.

uncovered by erosion are progressively older from west to east. On a geological map these appear as broad bands running roughly northwest-southeast (Figure 5).

The eastern and northern boundaries of Palaeozoic outcrop run roughly through the southern borders of Muskoka and Haliburton to just east of Kingston. Along this line, Ordovician rocks lap onto the Precambrian rocks of the Canadian Shield, which once formed the ocean shore. In places, sandstones are revealed, and one can picture them as ancient sandy beaches. The Ordovician rocks of Ontario abound with fossil snails, clams, squid-like nautiloids, trilobites, starfish, and sea lilies.

Different fossils indicate different ancient environments, in the same way that modern animals and plants are typical of certain habitats. For example, sea lilies, starfish, and some types of snails required a firm sea floor and clean sunny water with slight currents (Figure 6). Some clams, on the other hand, required a muddy sea

floor in which to burrow. These different environments are reflected in the types of rock in which the fossils occur. For instance, shale is simply fine mud, compacted and hardened. Sandstone was once loose sand such as is found on many beaches, the grains of which have become cemented together. Limestone is formed from calcium carbonate mud and the broken shells or stony skeletons of animals without backbones, *invertebrates*, living in the shallow tropical seawater.

The Niagara Escarpment, from the Niagara River to the Bruce Peninsula, marks the eastern boundary of outcrop of Silurian rocks. A well-known topographic feature, the escarpment reveals about 30 million years of Ontario's history in the rock strata it exposes. During late Ordovician and early Silurian time, the area from north of Hamilton to the Niagara Peninsula and into New York was part of a giant delta formed by rivers draining highlands to the southeast. In these delta deposits, fossils are scarce; often only the remains of worm burrows give any indication of what once lived there. The main evidence is found in the sediments, which become finer or muddier to the west and north and coarser or sandier to the south and east. This suggests that there was a shoreline to the southeast, because fine sediment is usually deposited in deeper, quieter water, while coarser sediment is deposited in more turbulent, shallow water. Particles in the deposits appear to have been derived by erosion of Precambrian rocks exposed in the Appalachian region. On the surfaces of some of the rock beds are preserved wave ripples identical to those formed today in the shallow water along beaches. Later the sea spread farther eastward, flooding the delta, and fossils are more numerous in the resulting sediments. During the Silurian period corals first started forming reefs. Some examples of early coral reefs are now exposed as fossils on Manitoulin Island (Figure 7).

The thickest deposits of Palaeozoic rock occur in southwestern Ontario. Here drilling has revealed rocks of Devonian age overlying a nearly complete succession of Ordovician and Silurian rocks. In the vicinity of Sarnia, oil and natural gas have been discovered, formed from the decayed bodies of ancient sea creatures and trapped mainly within rock strata of Ordovician and Silurian age. The Devonian rocks on the shore of Lake Huron, for example at Kettle Point, contain fossils of early land plants, which were washed into the sea. Middle Devonian rocks contain abundant fossil corals as well as trilobites, sea lilies, and other marine invertebrates (Figure 8). The bony skin plates of early armoured fish have occasionally been found.

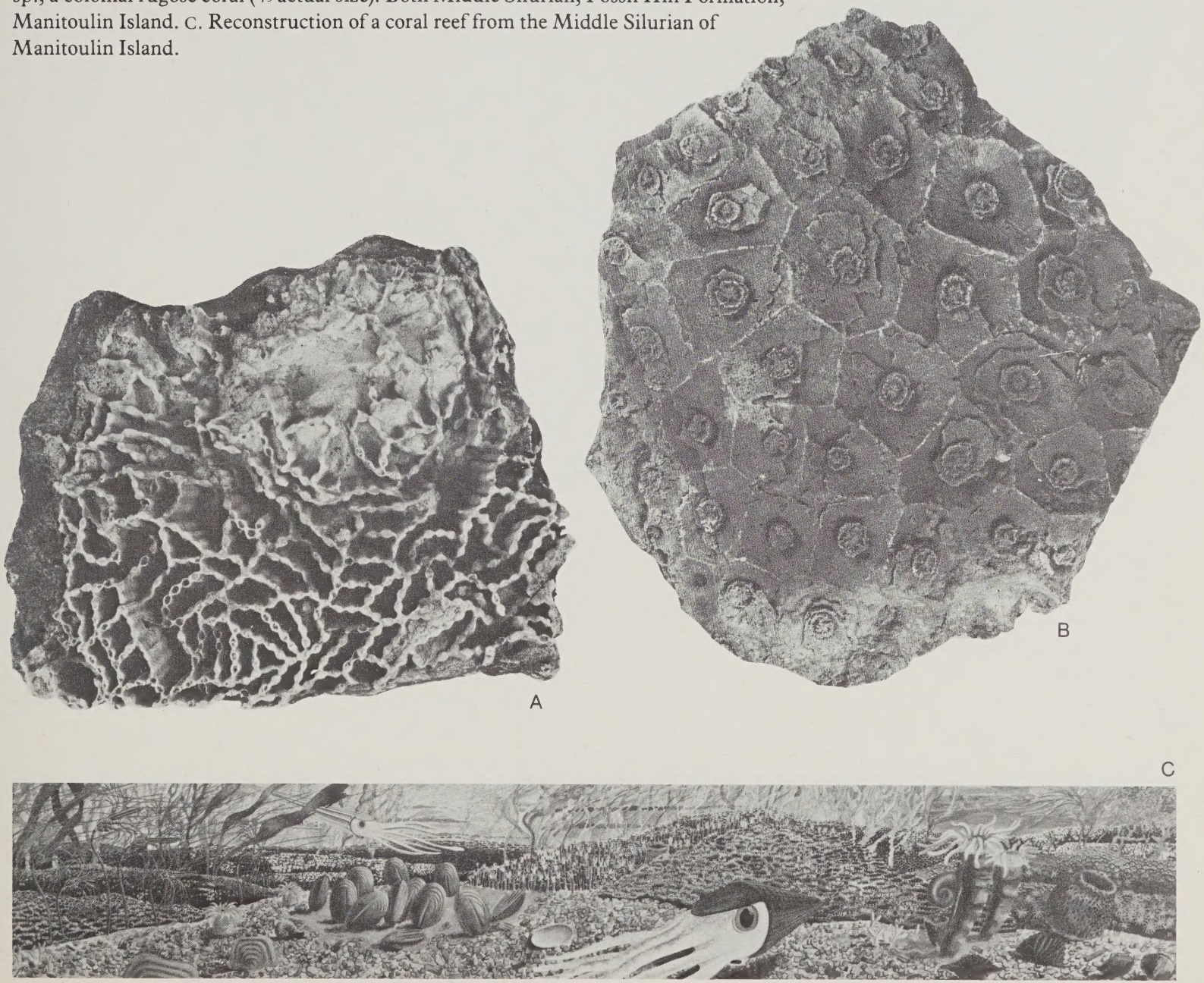
The Palaeozoic rocks of Hudson Bay and the James Bay Lowlands are less well known, but they tell much the same story as those of southern Ontario. In the Palaeozoic era seas covered a much larger area of Ontario than is suggested by the area now covered by the sediments. There is evidence for this in a few areas of Palaeozoic sediment called outliers which escaped removal by erosion and now stand as isolated pockets in the Precambrian rocks of the Canadian Shield. The Ordovician and Silurian rocks around Lake Timiskaming form one such outlier.

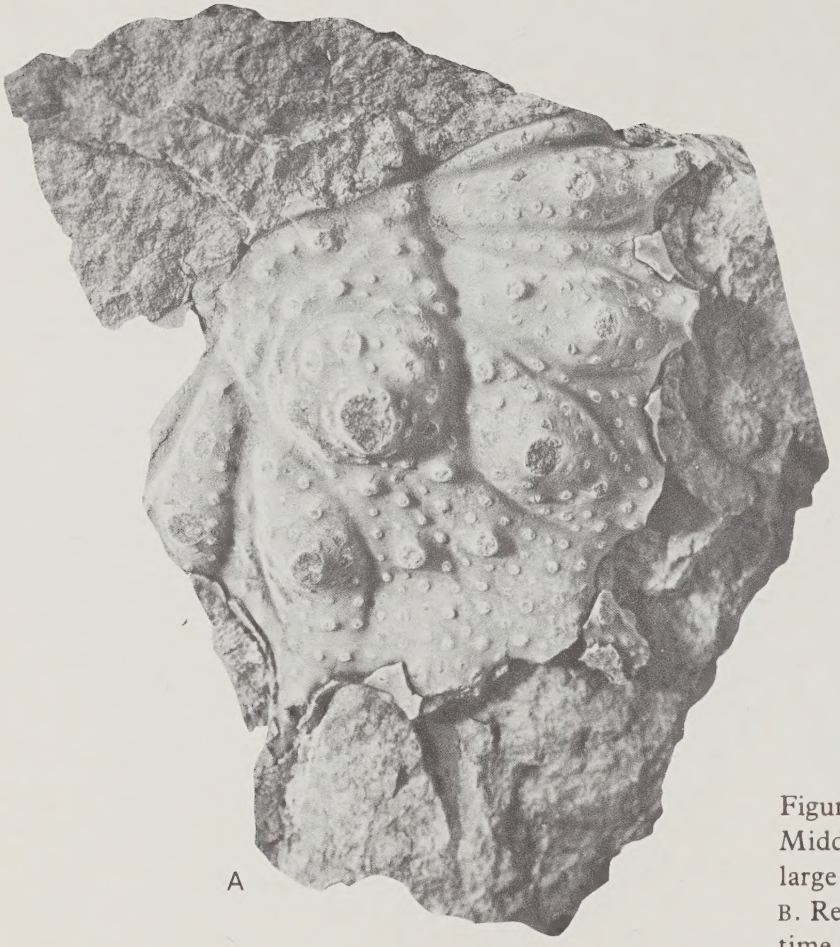
Cenozoic

Except for some poorly known deposits of Mesozoic age in the James Bay Lowlands, the next 350 million years are missing from Ontario's diary. Was no sediment deposited in Ontario over such a vast length of time? What is more probable is that sediments did accumulate and were later removed by erosion.

The next major chapter in Ontario's history is found in the loose unconsolidated deposits of the Pleistocene Epoch or Great Ice Age. Starting about one millon years

Figure 7 A. *Halysites* sp., a tabulate "chain" coral (9/10 actual size). B. *Arachnophyllum* sp., a colonial rugose coral (2/3 actual size). Both Middle Silurian, Fossil Hill Formation, Manitoulin Island. C. Reconstruction of a coral reef from the Middle Silurian of Manitoulin Island.





A

Figure 8 A. Part of the tail of the trilobite *Terataspis grandis*. Middle Devonian, Bois Blanc Formation, Port Colborne. This large trilobite is known only from fragments (9/10 actual size). B. Reconstruction of the sea-floor scene during Middle Devonian time, based on fossils from Port Colborne. The large trilobite to the right is *Terataspis*.

B

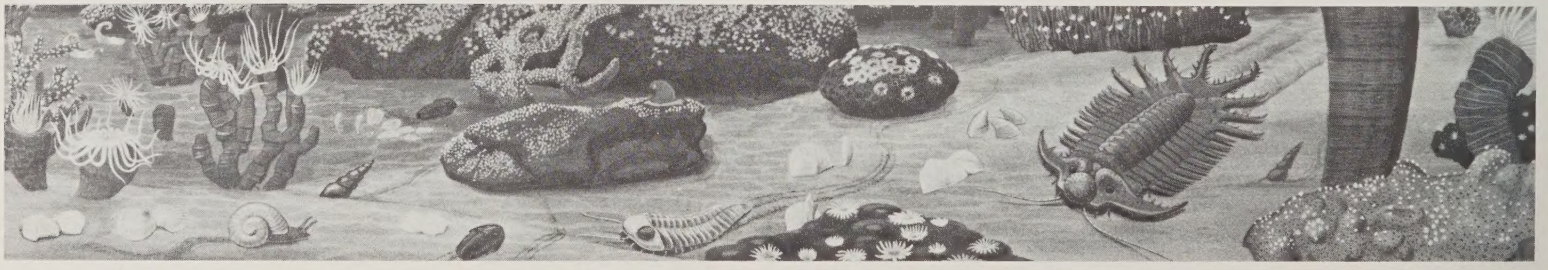


Figure 9 Collecting the leg bone of a Pleistocene mastodon near Ridgemount.

ago great glaciers spread southward, covering Ontario and much of the United States with ice, often more than a kilometre thick. Eventually the glaciers melted back, and then advanced again. This happened at least four times. When the ice was advancing, during *glacial* stages, it scoured and scraped the underlying landscape, picking up, crushing, and moving huge volumes of rock and soil. When it was retreating, during the *interglacial* stages, the meltwaters formed vast rivers and lakes, shifting the sediment still further. Meanwhile, on the exposed land, life flourished briefly in a milder climate than we know today.

By the end of the Ice Age, only 10 500 years or so ago, hundreds of metres of sand, silt, and gravel had been deposited in parts of Ontario, covering the older rock. These deposits are important today in providing sources of sand and gravel for the construction industry. They also contain a fascinating record of the life and climate of the Pleistocene. One of the most complete successions of interglacial sediment is exposed in the Toronto Brick Company quarry in Toronto. The fossils found here include wood from varieties of trees which now live along the Mississippi, as well as insects and numerous species of freshwater clams and snails. Among larger remains found near Toronto are the antlers of deer and the skulls of large bears, groundhogs, bison, and a giant beaver. Near Welland the remains of several mastodons, huge extinct woolly elephants, have been uncovered (Figure 9). Fossil pollen grains extracted from cores of lake mud provide a detailed record of the changes in vegetation through the years.

The fossils

Most of the fossils found in Ontario are the remains of invertebrates that lived in the sea, such as clams, snails, crustaceans, and corals. In some places there are plant fossils, and very rarely bones of fossil fish or other animals with backbones, *vertebrates,* may be found, especially in the deposits of Pleistocene time.

Many fossils are quite easy to recognize since they weather out of their surrounding rock and appear as three-dimensional shapes. Often, however, we find only outlines on the surface of the rock and must try to discover what the fossils are from a cross-section, just as we might try to identify different fruits in a slice of Christmas cake by their shapes.

Fossils can be classified by their appearance in much the same way as living animals and plants are. Some fossils frequently found in Ontario are described below, and many of them have close relatives living today.

Sponges

These are simple aquatic animals which get their food by filtering water through tiny pores to trap microscopic particles suspended in the water. The natural bath sponge is the skeleton of such an animal.

Some sponges, including many fossil varieties, have a skeleton of a fine network of tiny silica shards or spicules, which resist decay better than the soft skeleton of the bath sponge. After the animal dies, the spicules usually fall apart and are scattered.

Fossil sponges are known from rocks as old as the Cambrian. In Ontario they are particularly abundant in Silurian rocks of the Niagara Escarpment, where they are preserved as nearly spherical nodules of chert (Figure 10).

Corals

The word evokes pictures of shipwrecks on submerged reefs built up of the sea creatures' stony skeletons, but corals have lived in the sea since long before ships sailed (corals live only in the sea). Two extinct groups of coral are found as fossils in Ontario—rugose and tabulate.

Solitary rugose corals formed a stony skeleton shaped like a cone or a cornucopia. The interior of the cone was divided by numerous vertical walls running towards the centre like cuts made in a pie. The soft tissue of the animal, which is not preserved, was attached to the surface ridges formed by these walls at the mouth of the cone.

Colonial rugose corals consisted of many individuals growing together as a community, often so closely that their outer walls were shared and the tissues of individuals were joined.

Tabulate corals grew only as colonies. Externally their skeletons resemble some of the more closely packed rugose corals, but internally their structure is quite distinct. Instead of having prominent vertical walls, the individual tubes are divided by horizontal platforms.

A third group of corals, the *scleractinians,* which includes all corals living today, had not yet developed when Ontario's Palaeozoic sediments were being deposited.

Coral fossils are known in rocks from Ordovician to Recent in age. In Ontario they are especially common in the Silurian rocks of Manitoulin Island and in the Devonian deposits of southwestern Ontario and the shores of the Abitibi River (Figure 11).

Figure 10 *Caryomanon stellatum,* a sponge. A chert nodule has been cut in half, showing internal structure of the sponge preserved. Middle Silurian, Lockport Group, Hamilton (3 times actual size).

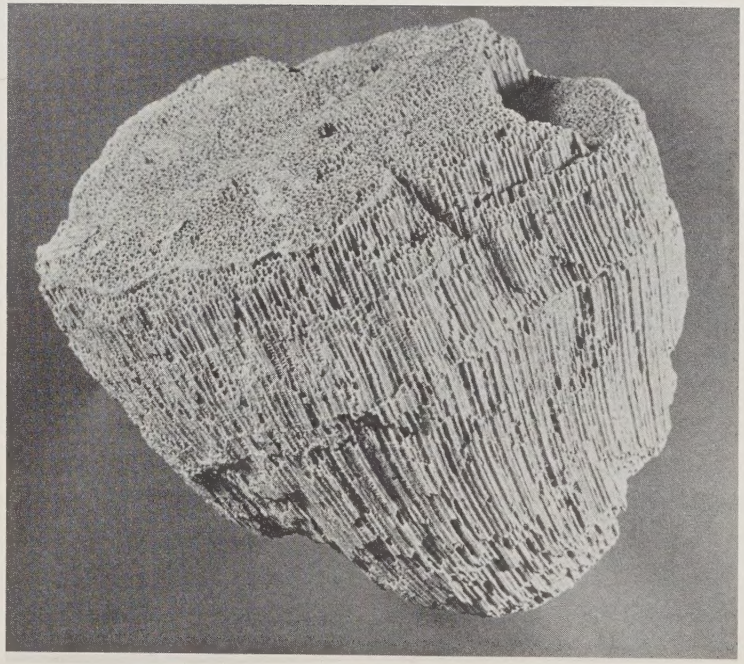


Figure 11 A. *Heliophyllum halli*, a solitary rugose coral. Middle Devonian, Hungry Hollow Formation, near Thedford (1 1/4 times actual size). B. *Emmonsia tuberosa,* tabulate coral. Middle Devonian, Coral Rapids, Abitibi River (1/4 actual size).

Stromatoporoids

These animals, now extinct, resembled corals in that their moundlike layered skeletons formed reefs. It is uncertain whether stromatoporoids were more closely allied to corals or to sponges. Their fossil remains are common in Ontario, especially in Ordovician rocks of the Ottawa and Lake Timiskaming areas, in Devonian sediments of Port Colborne, and in the Palaeozoic rocks of the James Bay Lowlands (Figure 12).

Bryozoans

This is another group of animals that build communal skeletons made up of tiny tubes or chambers. They are totally different from corals, both in the more complex structures of their living tissue and in details of their skeletons. In ancient times many bryozoans lived on or near coral reefs, just as they do today.

Bryozoan fossils show many different habits. They may form a crust on shells, they may form small mounds or branching or sticklike growths, or they may occur as a delicate lacy network. Regardless of the overall size of the specimen, the openings of the individual chambers are almost always much smaller than those of corals.

Bryozoans have existed from the Ordovician, and possibly the Cambrian, to the present. They are extremely common as fossils in the Ordovician rocks of the Toronto and Lake Simcoe areas (Figure 13).

Molluscs

Living molluscs are characterized by their soft fleshy bodies, although many are better known by their distinctive protective shells. Three main groups of molluscs—gastropods, bivalves, and cephalopods—occur commonly as fossils in Ontario, and can be identified from the altered remains of their shells.

Gastropods include snails and slugs. Fossil snails are known from rocks as old as Cambrian. They are especially common in Ontario rocks of Ordovician age in the Kingston and Lake Simcoe areas (Figure 14). Although less abundant, fossil snails may also be found in the Silurian rocks of Manitoulin Island and in the Devonian deposits of Lambton County. The fossil shells of freshwater snails occur abundantly in Pleistocene sediments, for example, north of Lake Superior, in the Toronto Brick Company quarry, and along the Scarborough Bluffs.

Bivalves or *pelecypods* include the clams, scallops, mussels, and oysters. They all have two shells which are hinged together and held shut by powerful muscles. Bivalves have existed since the Ordovician. Fossil species of Palaeozoic age occur in several Ontario localities although they are not usually abundant. Ordovician bivalves are quite common in rocks of the Toronto area (Figure 15). Moulds of the interiors of large clam shells may be found in Silurian rocks near Elora. The fossil shells of freshwater clams occur abundantly in Pleistocene interglacial sediments in the Toronto Brick Company quarry and elsewhere.

Cephalopods include the living chambered *Nautilus* as well as octopuses and squids. The fossil cephalopods found in Ontario are tapered conical or coiled shells divided into chambers by crosswalls called septa. They were probably predators or scavengers, with a squidlike body filling the last chamber at the open end of the shell. A connecting tube passes through the chambers of cephalopod shells making some fossils look like fish backbones.

Fossil cephalopods may be classified further according to the septa. In *nautiloids* the septa form smooth straight

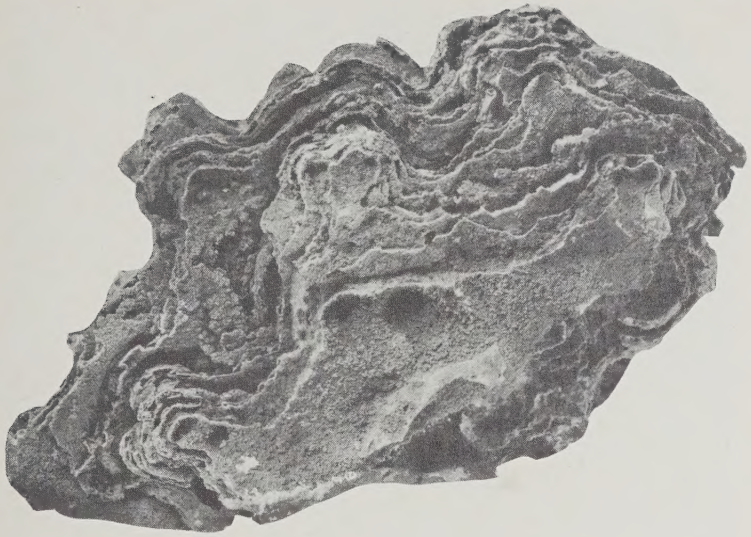


Figure 12 *Stromatocerium rugosum,* a stromatoporoid. Middle Ordovician, Black River Group, near Ottawa (1/2 actual size).

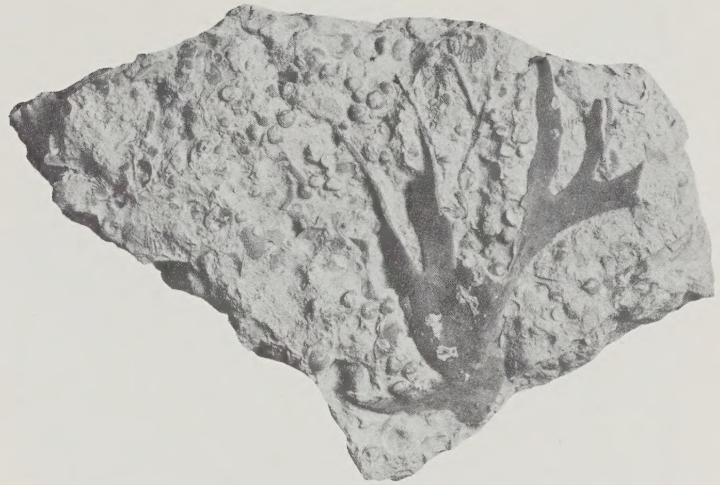


Figure 13 *Pachydictya* sp., a straplike bryozoan. Middle Ordovician, Verulam Formation, Gamebridge (1/2 actual size).

Figure 14 Slab of rock containing internal moulds of several different types of snail shells. Middle Ordovician, Verulam Formation, Gamebridge (2/3 actual size).

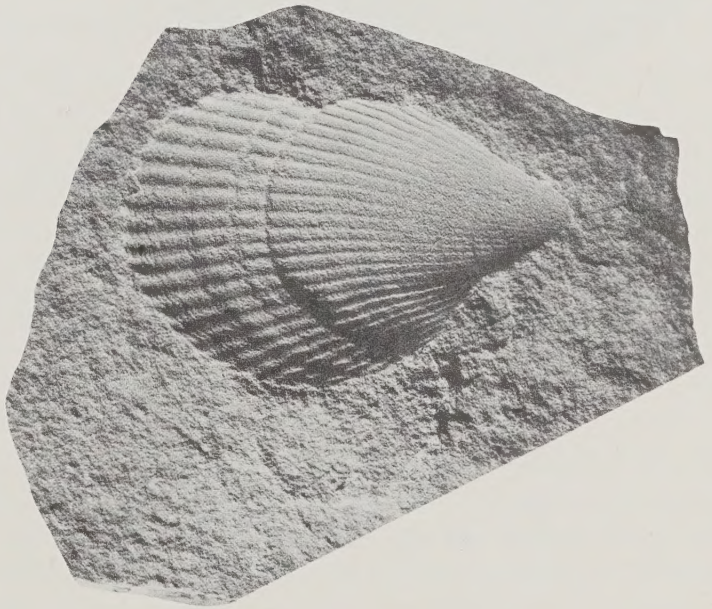


Figure 15 *Ambonychia radiata,* a mussel. Upper Ordovician, Georgian Bay Formation, Toronto (1 1/3 times actual size).

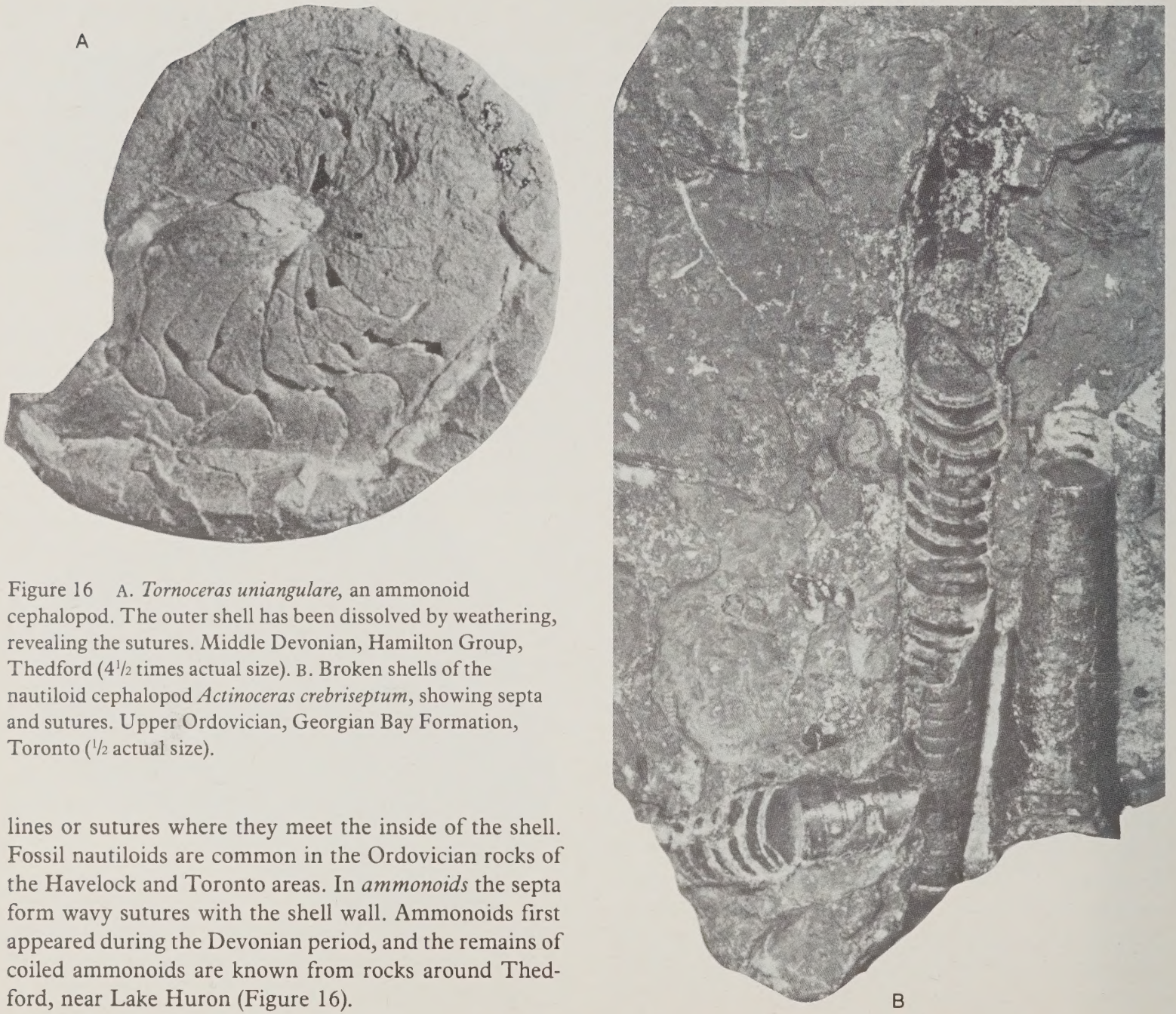
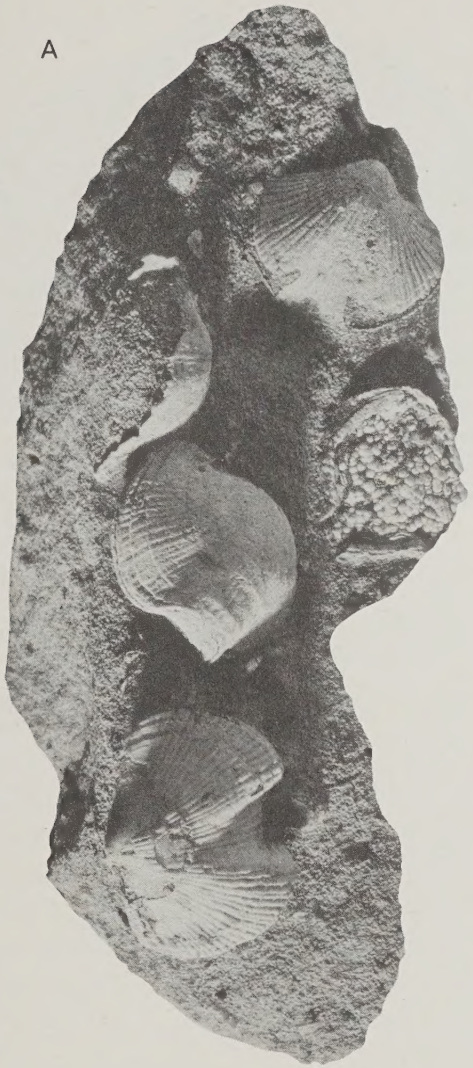


Figure 16 A. *Tornoceras uniangulare,* an ammonoid cephalopod. The outer shell has been dissolved by weathering, revealing the sutures. Middle Devonian, Hamilton Group, Thedford (4½ times actual size). B. Broken shells of the nautiloid cephalopod *Actinoceras crebriseptum*, showing septa and sutures. Upper Ordovician, Georgian Bay Formation, Toronto (½ actual size).

lines or sutures where they meet the inside of the shell. Fossil nautiloids are common in the Ordovician rocks of the Havelock and Toronto areas. In *ammonoids* the septa form wavy sutures with the shell wall. Ammonoids first appeared during the Devonian period, and the remains of coiled ammonoids are known from rocks around Thedford, near Lake Huron (Figure 16).



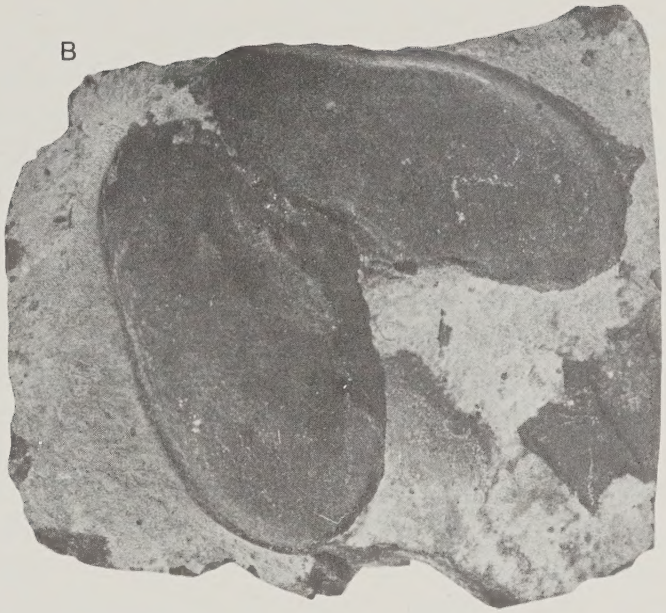


Figure 17 A. Several shells of the brachiopod *Atrypa parksi.* Note the symmetry of the shells. Lower Silurian, Manitoulin Island (1¼ times actual size). B. *Ctenodonta nasuta,* a bivalve with the two shells opened flat. Middle Ordovician, Gull River Formation, Waubaushene (twice actual size).

Brachiopods

These are animals that superficially resemble clams in that they have two shells, although internally they are quite different. They may be distinguished from clams by the shapes of their two shells. Each shell of the brachiopod is symmetrical about a centre line, although the individual shells may be quite different (Figure 17A). With clams the opposite is true: the individual shells are not symmetrical, but they have similar shapes (Figure 17B). Brachiopods live on the sea floor—buried in the mud, resting on the surface, or attached to some object such as another shell or a rock. They feed by filtering tiny organisms from the seawater.

Brachiopods have existed since early Cambrian time and some forms have changed very little to the present day. During the Palaeozoic era brachiopods were extremely common and they are now among the most abundant Ontario fossils.

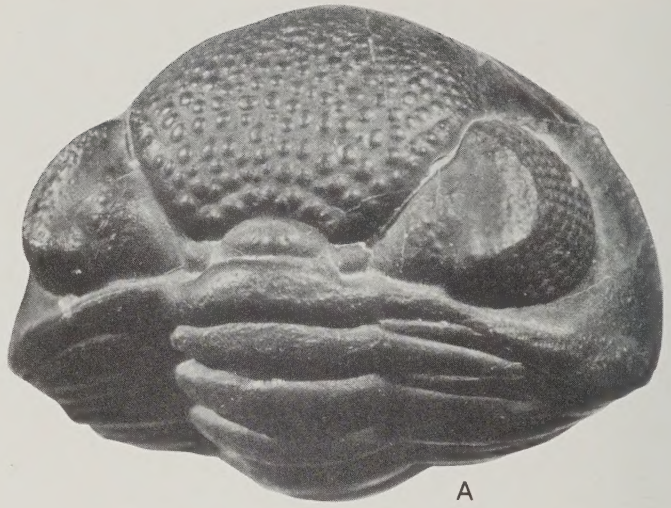
Arthropods

These make up the largest group of animals alive today. Living representatives include insects, spiders, lobsters, crabs, and barnacles. Two important groups, trilobites and eurypterids, occur only as fossils.

Trilobites are so named because their bodies were divided lengthwise by furrows into three more or less distinct lobes. They were also divided crosswise into three sections—a head shield or cephalon, a central segmented thorax, and a tail or pygidium. Many had well-defined eyes and it is easy to picture them scurrying about on the sea floor or burrowing in the mud in search of food and shelter. Like lobsters, trilobites grew by moulting. As they grew, they periodically shed their hard outer skeleton or *exoskeleton* and grew a new slightly larger one. Many trilobite remains found in the rock are just preserved pieces of discarded exoskeleton; the remains of an entire animal are found much less frequently.

Trilobites existed from the Cambrian to the Permian, when they became extinct. They are common Ontario fossils, especially in the Ordovician rocks around Collingwood and in the Devonian rocks of the London region (Figure 18).

Eurypterids or sea scorpions, related to horseshoe crabs of today, were probably predators, preying on smaller invertebrates such as trilobites, snails, and worms. They are found as fossils in Upper Silurian rocks near Fort Erie (Figure 19).



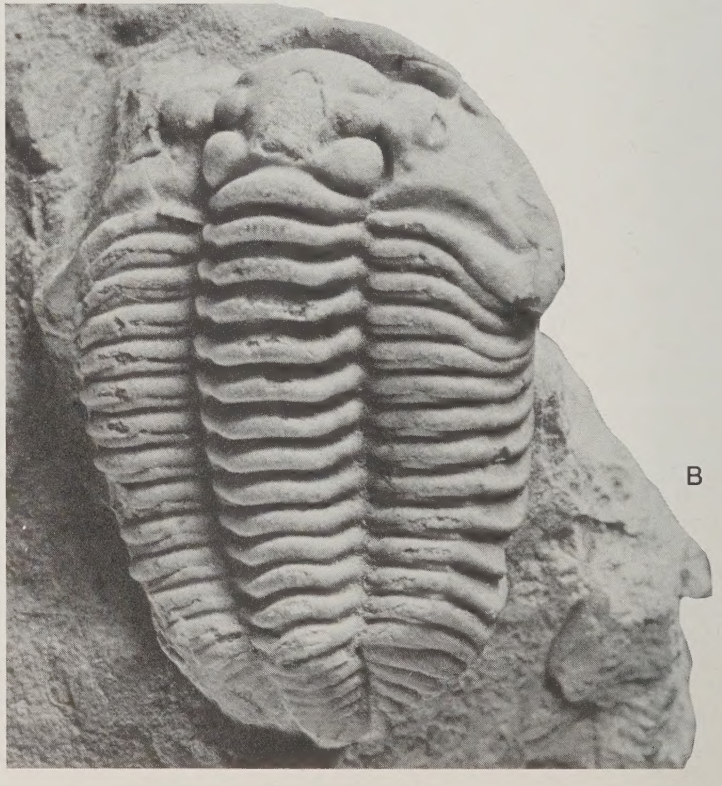


Figure 18 A. *Phacops rana*, a trilobite. Middle Devonian, Hamilton Group, Lambton County (2½ times actual size). B. *Calymene niagarensis*, a trilobite. Middle Silurian, Credit Forks (twice actual size).

Figure 19 A. *Eurypterus lacustris,* a sea scorpion. Upper Silurian, Bertie Formation, near Ridgeway ($^1/_2$ actual size). B. Reconstruction showing the lagoonal environment in which the eurypterids are thought to have lived.

B

Echinoderms

This group includes starfish, brittle stars, sea lilies, and sea urchins. These strange animals all possess a skeleton made up of a series of calcite plates which may be fused together, as they are in sea urchins, or joined by muscle tissue, as they are in sea stars and most sea lilies.

Sea lilies or *crinoids,* which have existed since the Ordovician, are so named because they resemble flowers, and for many years they were thought to be plants. Living crinoids consist of a cuplike body with feathery arms, in some cases supported by a stem made up of hundreds of small discs connected by muscle tissue. When the animal dies the soft tissue decays, and the plates and discs forming the body and stem are usually scattered on the sea floor. These discs, called columnals, are very common fossils in the Palaeozoic rocks of Ontario (Figure 20). In fact, some limestones consist of nothing but crinoid columnals cemented together. Because the skeletons of crinoids were so easily separated, whole fossil specimens are relatively rare. They have been found in Ordovician rocks of the Lake Simcoe area, and in Silurian shales of the Niagara Gorge.

Sea stars are quite easy to recognize, but occur relatively rarely as fossils. This does not necessarily mean that sea stars were rare in the past. Starfish and brittle stars today tend to inhabit tidal areas with fairly strong currents or wave action where their bodies may be destroyed rather than buried after death. Fossil starfish and brittle stars have been found in Ordovician rocks near Lake Simcoe (Figure 21) and in Silurian rocks in the Niagara Gorge.

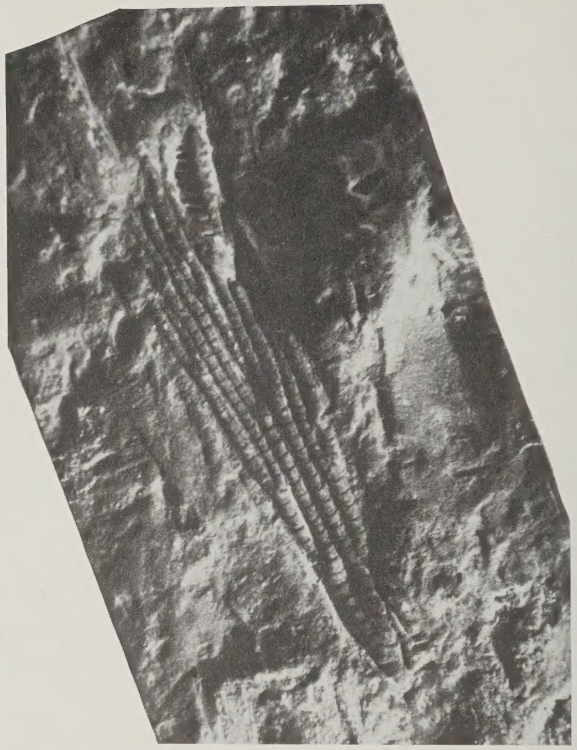


Figure 20 A. Body and arms of the crinoid *Dendrocrinus dyeri* ($1\frac{2}{3}$ times actual size). B. Crinoid columnals frequently make up a large proportion of the rock ($\frac{1}{2}$ actual size). Both Upper Ordovician, Georgian Bay Formation, Toronto.

Graptolites

These appear most often as black marks resembling tiny hacksaw blades in the rock. These strange extinct animals, which may have been related to vertebrates, lived as floating colonies formed of budlike individuals on a stick-shaped or bush-shaped skeleton. They are found in Ontario rocks of Ordovician age near Collingwood and in Silurian rocks along the Niagara Escarpment (Figure 22).

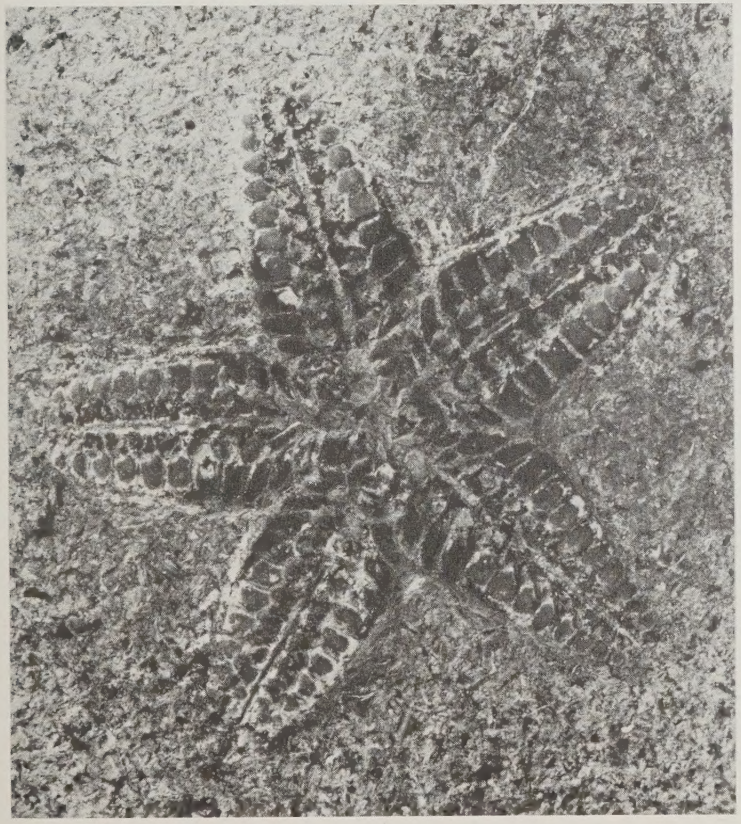


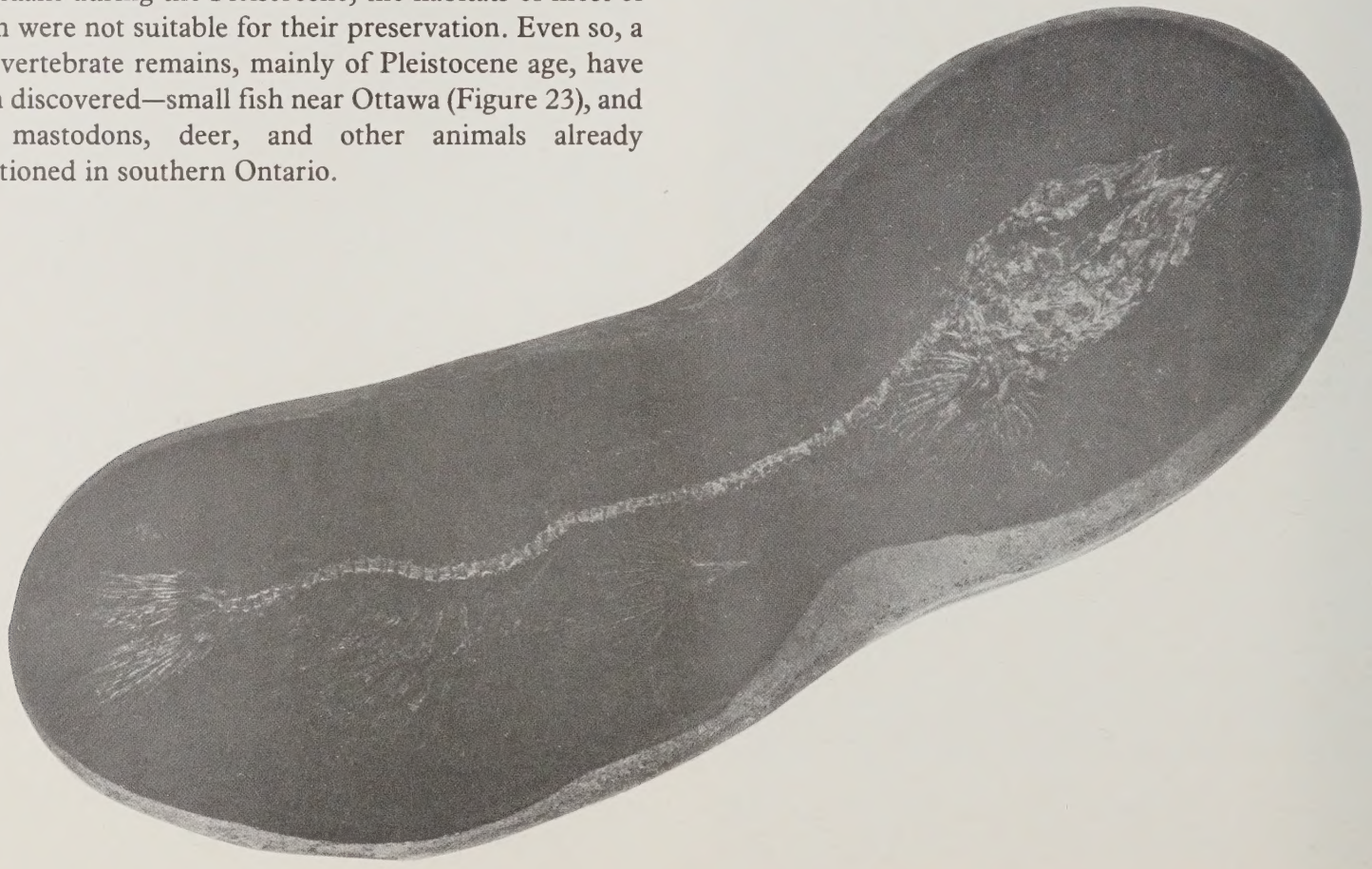
Figure 21 *Stenaster salteri,* a brittle star. Middle Ordovician, Bobcaygeon Formation, Kirkfield (5 times actual size).

Figure 22 Slab of rock with several examples of the graptolite *Glossograptus quadrimucronatus*. Upper Ordovician, Whitby Formation, Craigleith (actual size).

Vertebrates

The remains of vertebrates are relatively rare as fossils in Ontario. There are several reasons for this. Remember that only a tiny percentage of organisms ever become fossils. Today, and even more so in the past, invertebrates make up the vast majority of animals. Although primitive fish undoubtedly swam in Ontario's Palaeozoic seas, they were not abundant. Moreover, the bones of many fish are delicate and often soft, making them poor candidates for fossilization. While land vertebrates must have been abundant during the Pleistocene, the habitats of most of them were not suitable for their preservation. Even so, a few vertebrate remains, mainly of Pleistocene age, have been discovered—small fish near Ottawa (Figure 23), and the mastodons, deer, and other animals already mentioned in southern Ontario.

Figure 23 During the last Pleistocene interglacial stage, the ocean covered the Ottawa area. The remains of small fish are preserved in concretions in the deposits laid down at this time. *Mallotus villosus,* a herring or caplin. Pleistocene, near Ottawa (actual size).



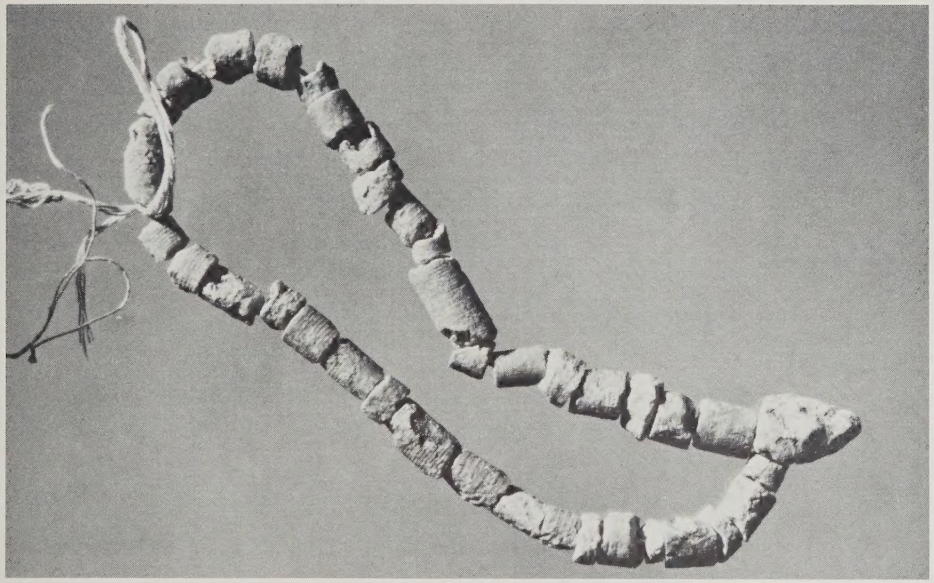


Figure 24 Necklace made from 400-million-year-old crinoid columnals (1/2 actual size).

Collecting fossils

Only a few fossils have been mentioned in this book, and only a few of the many places in which these fossils are found. Hundreds of different fossils have been reported in Ontario rocks, and many more have yet to be discovered. Fossils may be found almost anywhere that layered rocks are exposed—lakeshores and river banks, cliffs, road cuts, quarries, and other manmade excavations. In some areas with poor soil cover, fossils may be exposed on the surface of eroded sedimentary strata.

Collecting fossils is an interesting hobby as well as an important science. We have already seen how fossils contributed to the development of the geological time scale. They are important too in exploration for oil and natural gas as they provide a means of recognizing the strata in which these substances may be trapped. (In a way, oil and natural gas are fossils themselves since they represent the decayed remains of animals and plants.)

Fossil collecting is almost as old as mankind. A Jurassic brachiopod was found amongst amulets thought to have been used by Neanderthal Man. Magdalenian hunters, 15 000 years ago, made pendants from trilobites and carved stones to duplicate them. In southern France the Grimaldi cave dwellers used modern and fossil shells as ornaments. The fossils did not occur locally and must have been sought and collected for a particular purpose.

Over the ages fossils have seen many uses as ornaments and as amulets. They have been credited with miraculous healing powers, and fabulous stories have been made up about their creation. We now know what fossils are, and are beginning to understand what they can tell us. A greater understanding has removed some of the mystery of fossils, but far from destroying our interest, this knowledge can only serve to increase it.

Suggested reading

Bolton, T. E., *Silurian Faunas of Ontario*. Geological Survey of Canada, Paper 66–5.

Geological Highway Map—Southern Ontario. Ontario Geological Survey, Map 2418.

Hewitt, D. F., *Geology and Scenery—Peterborough, Bancroft and Madoc Area.* Ontario Department of Mines, Geological Guidebook No. 3.

Hewitt, D. F., *Geology and Scenery—North Shore of Lake Huron Region.* Ontario Department of Mines, Geological Guidebook No. 4.

Kesling, R. V. and R. B. Chilman, *Strata and Megafossils of the Middle Devonian Silica Formation.* Michigan University, Museum of Paleontology, Papers on Paleontology, No. 8.

Ludvigsen, Rolf, *Fossils of Ontario, Part 1: The Trilobites.* Royal Ontario Museum, Life Sciences Miscellaneous Publication, Toronto.

McAlester, A. L., *The History of Life.* Foundations of Earth Science Series, Prentice-Hall, New Jersey.

Rhodes, F. H. T., H. S. Zim, and P. R. Shaffer, *Fossils—A Guide to Prehistoric Life.* A Golden Nature Guide, Golden Press, New York.

Verma, H. M., *Geology and Fossils of the Craigleith Area.* Ontario Geological Survey, Guidebook No. 7.

Student activities

1. What is a fossil? How are fossils formed?
2. Why is it that fossils give only a very incomplete picture of past life?
3. a) What is meant by *absolute* time and *relative* time?
   b) Describe briefly how each is determined.
4. Describe the scene in southern Ontario during the Ordovician period. What evidence is there to support your description?
5. In a gravel pit you may find different boulders containing fossils of several different ages. Why would this occur?
6. On a map of Ontario locate the following places: Toronto, London, Thunder Bay, Kingston, Sudbury, Sarnia, Peterborough, Collingwood, St. Catharines, North Bay.
   Consult the geological map (Figure 5) to determine the age of the rocks outcropping in each of these areas.
   At which of these places could you expect to find fossils? Why?
7. a) A drill hole near St. Catharines passes through sediments and rock of Ordovician, Pleistocene, Silurian, and Precambrian ages. Refer to Table 1 and arrange this sequence in the correct order from the top down (from younger to older).
   b) What ages of sediment and rock would a drill hole pass through near Sarnia? Near Toronto?
   c) Why wouldn't rocks of all ages be encountered in these drill holes?
8. How do brachiopods differ from clams? How are they similar?
9. Describe how a single trilobite might have left several potential fossils in its lifetime.
10. *Lingula* is a brachiopod that has existed, virtually unchanged, since the Cambrian period. *Pentamerus,* another brachiopod, lived only during the Silurian period. Which fossil is more useful in determining the age of the rocks in which it occurs? Why? How might several fossils with different time ranges be more useful for dating a particular rock layer than any one fossil alone?
11. Choose a familiar scene such as a construction site, a city parking lot, a beach, a forest, a farmyard. Try to picture how it would appear if it were buried for millions of years and then dug up again. Take into consideration animals, plants, and any structures that might remain.
    How might a palaeontologist from another planet interpret this fossil scene?
12. How old are the earliest fossils in Ontario? In the world? Why are Precambrian fossils so very rare?
    Consult books in your school library to find out more about Precambrian fossils.
13. Plan a trip to a local quarry or natural rock exposure to look for fossils. Be sure to get permission from the owner of the land and to observe safety precautions.
    a) Identify any fossils that you find and determine the type of preservation.
    b) How many types of preservation are represented in your collection?
    Explain how different fossils may be preserved differently in the same rock.

Another in the series of ROM publications entitled ROM ENCOUNTER SERIES, *An Introduction to Ontario Fossils* provides an insight into Ontario's fascinating past and the way that history can be read in the rocks. The book is well and generously illustrated and should not only stimulate interest in Ontario fossils but assist in the identification of some of them.

Other books in the series

The Great Lakes, Walter M. Tovell
The Niagara River, Walter M. Tovell

Several books now in preparation will focus on other important features of the Ontario landscape.

ISBN 0-88854-250-X